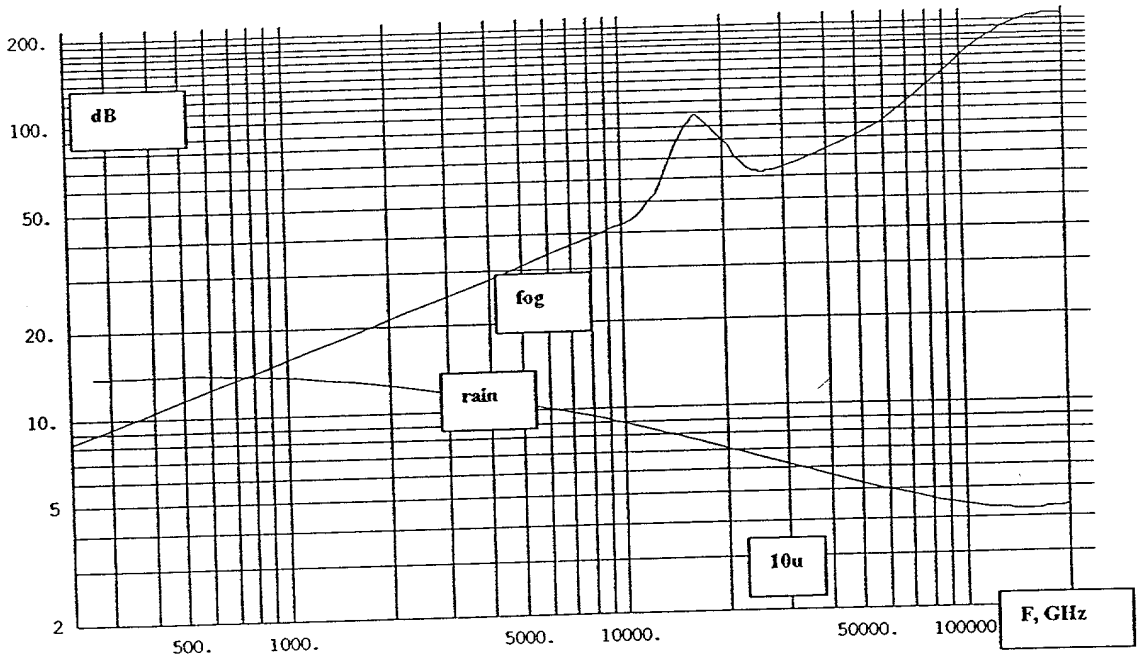
200.
100.
50.
20.
10.
5
2
dB
fog
rain
10u
500.
1000.
5000.
10000.
50000.
100000
F, GHz

Fig. 1

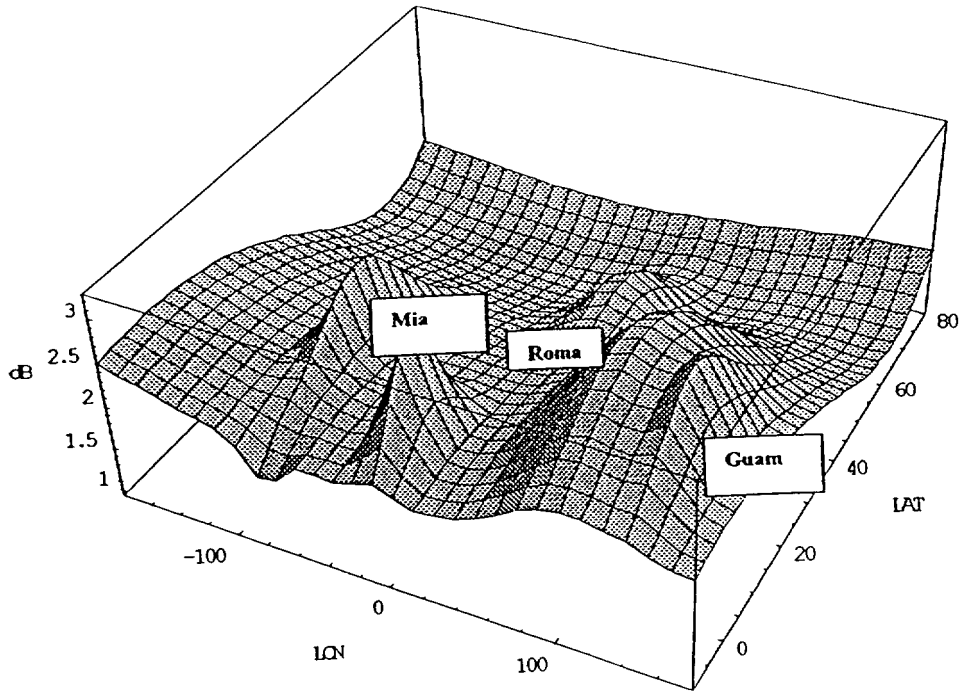
Mia
Roma
Guam
dB
3
2.5
2
1.5
1
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 2

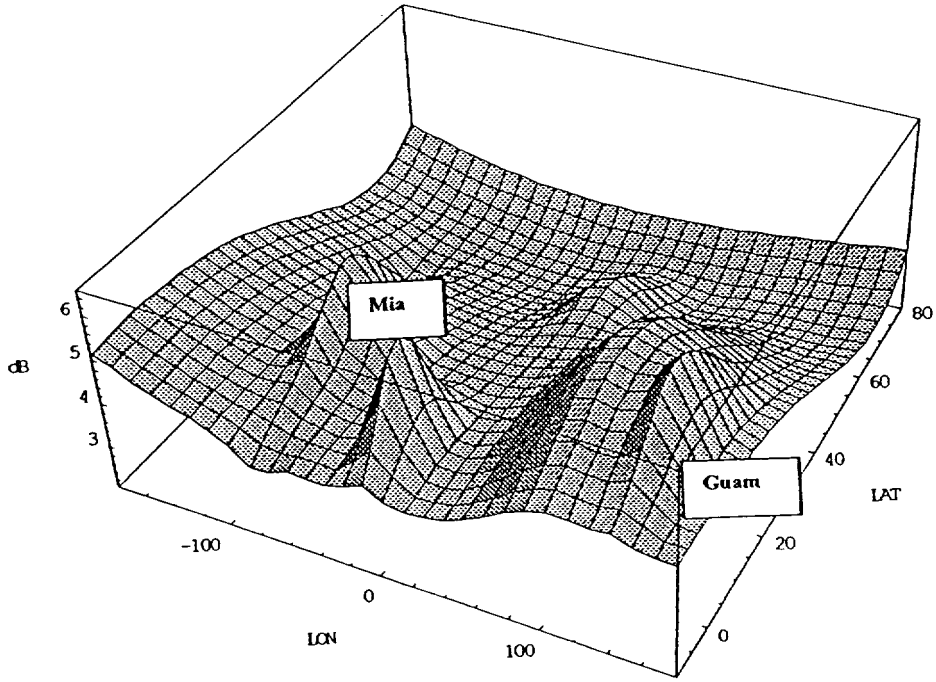
Mia
Guam
dB
6
5
4
3
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 3

Short Form Global Equation for Non Rainy Zenith Attenuation (dB) For the 6-100 GHz Region; fg=Frequency, GHz

LIEBE azen=

$$0.000408122 fg^2 \left(5.34566 + 1.48098E^{-\frac{1}{200}(10+LAT)^2-\frac{1}{200}(-145+LON)^2} + 2.03295E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} + 1.1968E^{-\frac{1}{200}(-52+LAT)^2-\frac{1}{800}(-28+LON)^2} - 2.78685E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 2.48024E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} + 1.41803E^{-\frac{1}{50}(-20+LAT)^2-\frac{1}{200}(60+LON)^2} - 2.26449E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} + 1.69839E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.000898808\,LAT - 0.00187405\,LAT^2 + 8.15535\times10^{-7}\,LAT^3 + 1.92203\times10^{-7}\,LAT^4 - 0.000690105\,LON - 5.83206\times10^{-6}\,LAT\,LON + 3.42574\times10^{-7}\,LAT^2\,LON + 0.0000243378\,LON^2 + 1.15354\times10^{-8}\,LATLON^2 - 3.5046\times10^{-8}\,LON^3 - 6.44437\times10^{-11}\,LON^4\right) +$$

$$0.00586939 fg^2 \left(3.14686 + 0.665394E^{-\frac{1}{200}(-10+LAT)^2-\frac{1}{200}(-145+LON)^2} + 1.1188E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} + 0.716478E^{-\frac{1}{200}(52+LAT)^2-\frac{1}{800}(-28+LON)^2} + 1.18012E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 1.21591E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} - 1.89544E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} + 0.8941E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.00101461\,LAT - 0.000943554\,LAT^2 + 2.75301\times10^{-7}\,LAT^3 + 1.00142\times10^{-7}\,LAT^4 - 0.000268921\,LON - 1.63982\times10^{-6}\,LATLON + 2.33496\times10^{-7}\,LAT^2\,LON + 0.0000108872\,LON^2 + 1.02349\times10^{-8}\,LATLON^2 - 1.77808\times10^{-8}\,LON^3 - 1.11299\times10^{-10}\,LON^4 -$$

$$0.201139 \left(5.34566 + 1.48098E^{-\frac{1}{200}(10+LAT)^2-\frac{1}{200}(-145+LON)^2} + 2.03295E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} + 1.1968E^{-\frac{1}{200}(-52+LAT)^2-\frac{1}{800}(-28+LON)^2} - 2.78685E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 2.48024E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} + 1.41803E^{-\frac{1}{50}(-20+LAT)^2-\frac{1}{200}(60+LON)^2} - 2.26449E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} + 1.69839E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.000898808\,LAT - 0.00187405\,LAT^2 + 8.15535\times10^{-7}\,LAT^3 + 1.92203\times10^{-7}\,LAT^4 - 0.000690105\,LON - 5.83206\times10^{-6}\,LAT\,LON + 3.42574\times10^{-7}\,LAT^2\,LON + 0.0000243378\,LON^2 + 1.15354\times10^{-8}\,LATLON^2 - 3.5046\times10^{-8}\,LON^3 - 6.44437\times10^{-11}\,LON^4\right)\Big)$$

$$\Big(0.665418 - 132.118\,(-0.740741 + 0.0333667\,fg)^2 \Big(0.999375 - 11.4943\sqrt{(-0.740741 + 0.0333667\,fg)^2}\ \text{ArcTan}\Big[\frac{0.0869456}{\sqrt{(-0.740741 + 0.0333667\,fg)^2}}\Big]\Big) - 132.118\,(0.740741 + 0.0333667\,fg)^2 \Big(0.999375 - 11.4943\sqrt{(0.740741 + 0.0333667\,fg)^2}\ \text{ArcTan}\Big[\frac{0.0869456}{\sqrt{(0.740741 + 0.0333667\,fg)^2}}\Big]\Big)\Big) -$$

$$0.00392386 fg^2 \Big(18.2482 \Big(\text{Log}\Big[\frac{(2 - 0.0333667\,fg)^2}{0.000749822 + (2 - 0.0333667\,fg)^2}\Big] + \text{Log}\Big[\frac{(3.95999999999999 - 0.0333667\,fg)^2}{0.000187456 + (3.95999999999999 - 0.0333667\,fg)^2}\Big] + \text{Log}\Big[\frac{(\frac{61}{10} - 0.0333667\,fg)^2}{0.000187456 + (\frac{61}{10} - 0.0333667\,fg)^2}\Big] + \text{Log}\Big[\frac{(2 + 0.0333667\,fg)^2}{0.000749822 + (2 + 0.0333667\,fg)^2}\Big] + \text{Log}\Big[\frac{(3.95999999999999 + 0.0333667\,fg)^2}{0.000187456 + (3.95999999999999 + 0.0333667\,fg)^2}\Big] + \text{Log}\Big[\frac{(\frac{61}{10} + 0.0333667\,fg)^2}{0.000187456 + (\frac{61}{10} + 0.0333667\,fg)^2}\Big]\Big) + 27.7778\,\text{Log}\Big[\frac{0.00111334\,fg^2}{0.000323595 + 0.00111334\,fg^2}\Big]\Big)$$

Fig. 4

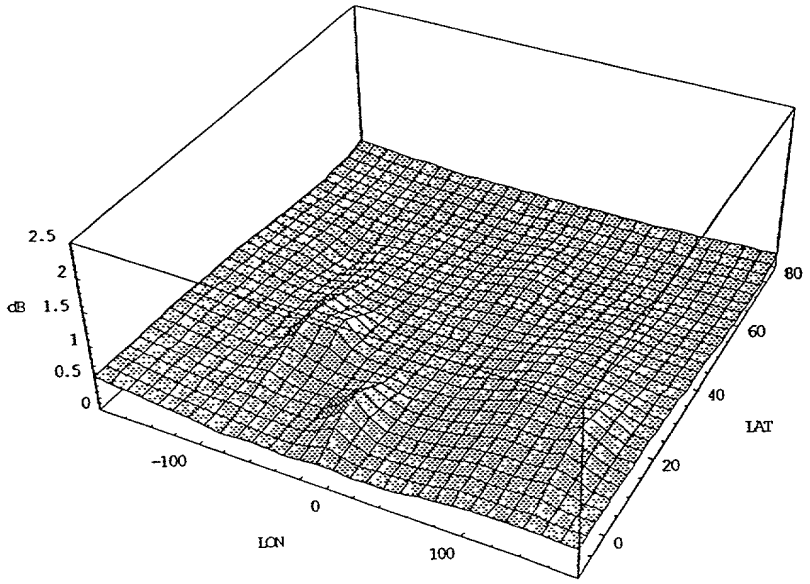
2.5
2
dB 1.5
1
0.5
0
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 5

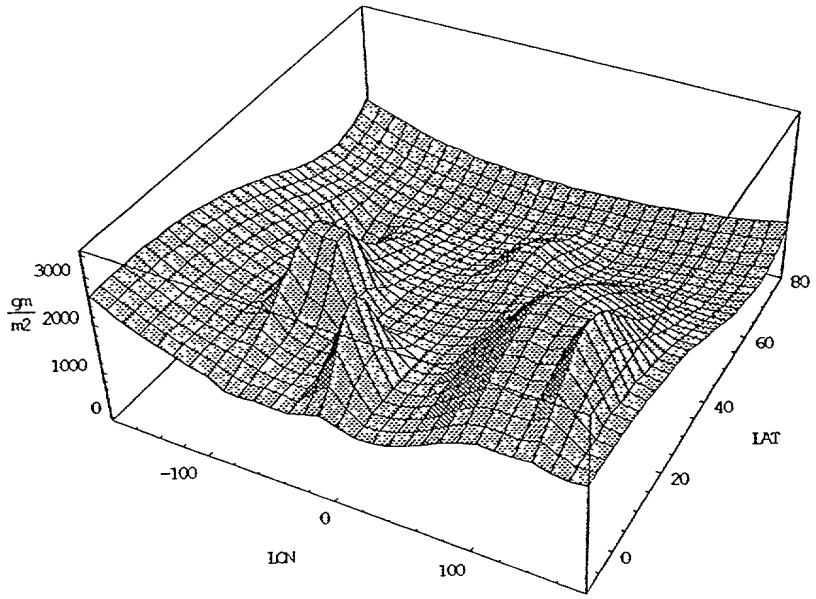
3000
gm/m2 2000
1000
0
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 6

$$
\begin{aligned}
&-1158.02 \\
&\Big(1.\Big(-0.139753\Big(1.79394\times10^{-7}\,LAT^4+8.75845\times10^{-7}\,LAT^3+3.25314\times10^{-7}\,LON\,LAT^2-0.00176137\,LAT^2+3.07508\times10^{-9}\,LON^2\,LAT-6.69472\times10^{-6}\,LON\,LAT+0.000919687 \\
&\quad LAT+1.49573\,e^{-\frac{1}{200}(LAT-10)^2-\frac{1}{200}(LON-145)^2}+2.04653\,e^{-\frac{1}{800}(LAT-18)^2-\frac{(LON-102)^2}{1800}}+1.16178\,e^{-\frac{1}{200}(LAT-52)^2-\frac{1}{800}(LON-28)^2}-2.51927\,e^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}}+ \\
&\quad 2.46395\,e^{-\frac{1}{72}(LAT-2)^2-\frac{1}{200}(LON-7)^2}+1.41489\,e^{-\frac{1}{50}(LAT-20)^2-\frac{1}{200}(LON-60)^2}-2.25769\,e^{-\frac{1}{200}(LAT-28)^2-\frac{1}{200}(LON-77)^2}+1.69814\,e^{-\frac{1}{200}(LAT-20)^2-\frac{1}{128}(LON-82)^2}- \\
&\quad 1.07578\,e^{-\frac{1}{98}(LAT-45)^2-\frac{1}{128}(LON-110)^2}-4.24764\times10^{-11}\,LON^4-3.34843\times10^{-8}\,LON^3+0.0000241438\,LON^2-0.000725197\,LON+3.84195\Big)+ \\
&\frac{1}{(293.-0.25\,(LAT-40.))^2}\Big(85849.\Big(0.139753\Big(1.79394\times10^{-7}\,LAT^4+8.75845\times10^{-7}\,LAT^3+3.25314\times10^{-7}\,LON\,LAT^2-0.00176137\,LAT^2+ \\
&\quad 3.07508\times10^{-9}\,LON^2\,LAT-6.69472\times10^{-6}\,LON\,LAT+0.000919687\,LAT+1.49573\,e^{-\frac{1}{200}(LAT-10)^2-\frac{1}{200}(LON-145)^2}+ \\
&\quad 2.04653\,e^{-\frac{1}{800}(LAT-18)^2-\frac{(LON-102)^2}{1800}}+1.16178\,e^{-\frac{1}{200}(LAT-52)^2-\frac{1}{800}(LON-28)^2}-2.51927\,e^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}}+2.46395\,e^{-\frac{1}{72}(LAT-2)^2-\frac{1}{200}(LON-7)^2}+ \\
&\quad 1.41489\,e^{-\frac{1}{50}(LAT-20)^2-\frac{1}{200}(LON-60)^2}-2.25769\,e^{-\frac{1}{200}(LAT-28)^2-\frac{1}{200}(LON-77)^2}+1.69814\,e^{-\frac{1}{200}(LAT-20)^2-\frac{1}{128}(LON-82)^2}- \\
&\quad 1.07578\,e^{-\frac{1}{98}(LAT-45)^2-\frac{1}{128}(LON-110)^2}-4.24764\times10^{-11}\,LON^4-3.34843\times10^{-8}\,LON^3+0.0000241438\,LON^2-0.000725197\,LON+3.84195\Big)+1.01966\Big)\Big)+ \\
&\Big(0.186801\Big(1.79394\times10^{-7}\,LAT^4+8.75845\times10^{-7}\,LAT^3+3.25314\times10^{-7}\,LON\,LAT^2-0.00176137\,LAT^2+3.07508\times10^{-9}\,LON^2\,LAT- \\
&\quad 6.69472\times10^{-6}\,LON\,LAT+0.000919687\,LAT+1.49573\,e^{-\frac{1}{200}(LAT-10)^2-\frac{1}{200}(LON-145)^2}+2.04653\,e^{-\frac{1}{800}(LAT-18)^2-\frac{(LON-102)^2}{1800}}+ \\
&\quad 1.16178\,e^{-\frac{1}{200}(LAT-52)^2-\frac{1}{800}(LON-28)^2}-2.51927\,e^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}}+2.46395\,e^{-\frac{1}{72}(LAT-2)^2-\frac{1}{200}(LON-7)^2}+1.41489\,e^{-\frac{1}{50}(LAT-20)^2-\frac{1}{200}(LON-60)^2}- \\
&\quad 2.25769\,e^{-\frac{1}{200}(LAT-28)^2-\frac{1}{200}(LON-77)^2}+1.69814\,e^{-\frac{1}{200}(LAT-20)^2-\frac{1}{128}(LON-82)^2}-1.07578\,e^{-\frac{1}{98}(LAT-45)^2-\frac{1}{128}(LON-110)^2}- \\
&\quad 4.24764\times10^{-11}\,LON^4-3.34843\times10^{-8}\,LON^3+0.0000241438\,LON^2-0.000725197\,LON+3.84195\Big)+0.332309\Big)\log(PR)-0.919661\Big)- \\
&0.764706\Big(-0.352549\Big(1.03045\times10^{-7}\,LAT^4+2.23192\times10^{-7}\,LAT^3+2.44557\times10^{-7}\,LON\,LAT^2-0.000975417\,LAT^2+1.0003\times10^{-8}\,LON^2\,LAT-2.18586\times10^{-6}\,LON\,LAT+ \\
&\quad 0.00128521\,LAT+0.66746\,e^{-\frac{1}{200}(LAT-10)^2-\frac{1}{200}(LON-145)^2}+1.12036\,e^{-\frac{1}{800}(LAT-18)^2-\frac{(LON-102)^2}{1800}}+0.70296\,e^{-\frac{1}{200}(LAT-52)^2-\frac{1}{800}(LON-28)^2}- \\
&\quad 1.28258\,e^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}}+1.22726\,e^{-\frac{1}{72}(LAT-2)^2-\frac{1}{200}(LON-7)^2}-1.92779\,e^{-\frac{1}{200}(LAT-28)^2-\frac{1}{200}(LON-77)^2}+0.865964\,e^{-\frac{1}{200}(LAT-20)^2-\frac{1}{128}(LON-82)^2}- \\
&\quad 0.0909198\,e^{-\frac{1}{98}(LAT-45)^2-\frac{1}{128}(LON-110)^2}-1.36816\times10^{-10}\,LON^4-1.38211\times10^{-8}\,LON^3+0.000011497\,LON^2-0.000416968\,LON+2.53967\Big)+ \\
&\Big(0.140592\Big(1.03045\times10^{-7}\,LAT^4+2.23192\times10^{-7}\,LAT^3+2.44557\times10^{-7}\,LON\,LAT^2-0.000975417\,LAT^2+1.0003\times10^{-8}\,LON^2\,LAT- \\
&\quad 2.18586\times10^{-6}\,LON\,LAT+0.00128521\,LAT+0.66746\,e^{-\frac{1}{200}(LAT-10)^2-\frac{1}{200}(LON-145)^2}+1.12036\,e^{-\frac{1}{800}(LAT-18)^2-\frac{(LON-102)^2}{1800}}+ \\
&\quad 0.70296\,e^{-\frac{1}{200}(LAT-52)^2-\frac{1}{800}(LON-28)^2}-1.28258\,e^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}}+1.22726\,e^{-\frac{1}{72}(LAT-2)^2-\frac{1}{200}(LON-7)^2}- \\
&\quad 1.92779\,e^{-\frac{1}{200}(LAT-28)^2-\frac{1}{200}(LON-77)^2}+0.865964\,e^{-\frac{1}{200}(LAT-20)^2-\frac{1}{128}(LON-82)^2}-0.0909198\,e^{-\frac{1}{98}(LAT-45)^2-\frac{1}{128}(LON-110)^2}- \\
&\quad 1.36816\times10^{-10}\,LON^4-1.38211\times10^{-8}\,LON^3+0.000011497\,LON^2-0.000416968\,LON+2.53967\Big)+0.132924\Big)\log(PR)-0.0878644\Big)\Big)
\end{aligned}
$$

Fig. 7

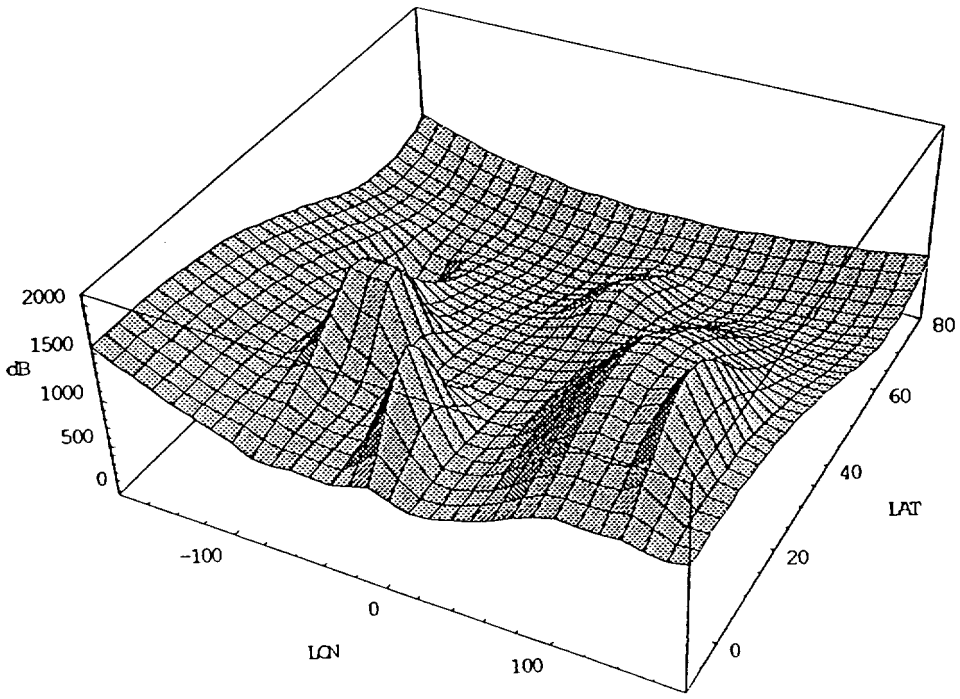

Fig. 8

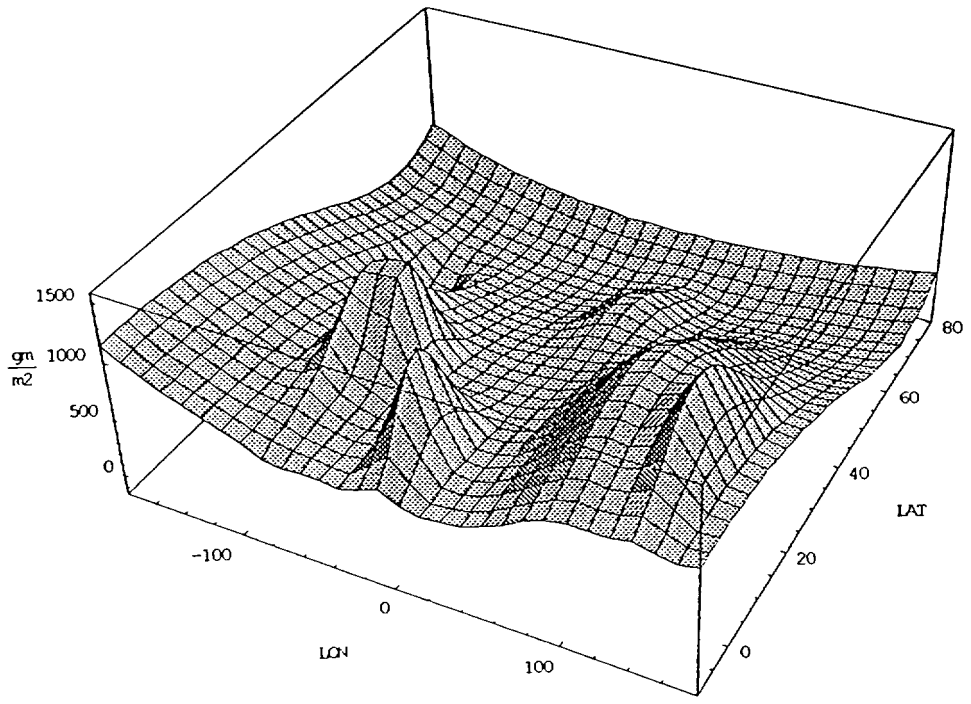

Fig. 9

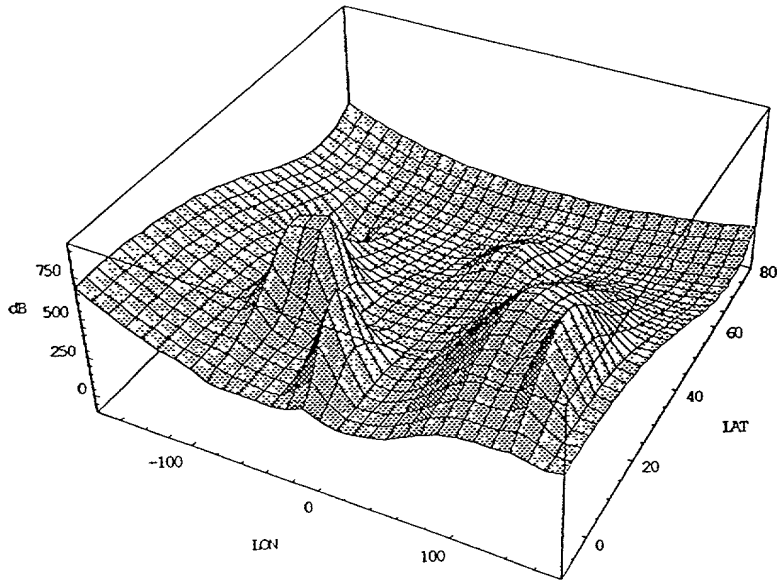
dB
750
500
250
0
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 10

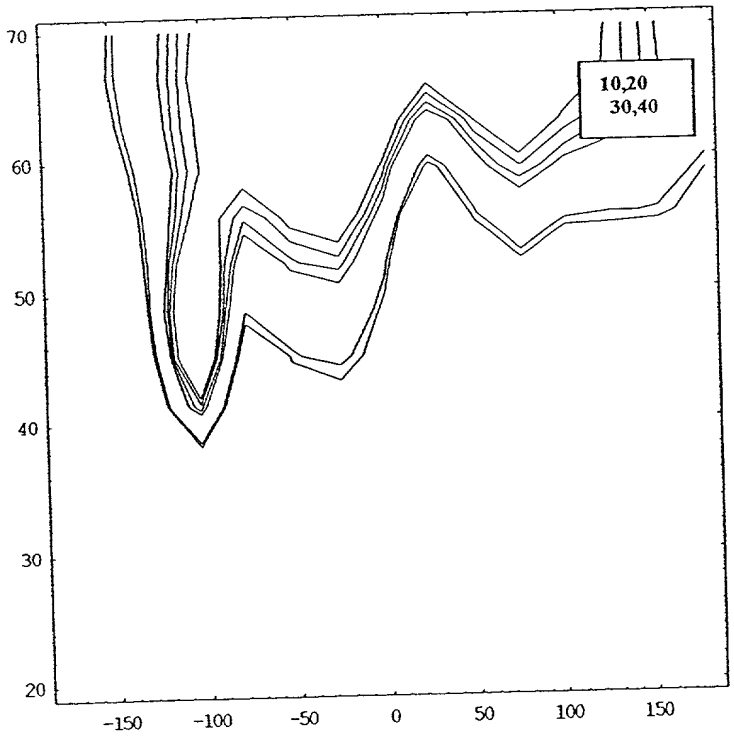
70
60
50
40
30
20
-150
-100
-50
0
50
100
150
10,20
30,40

Fig. 11

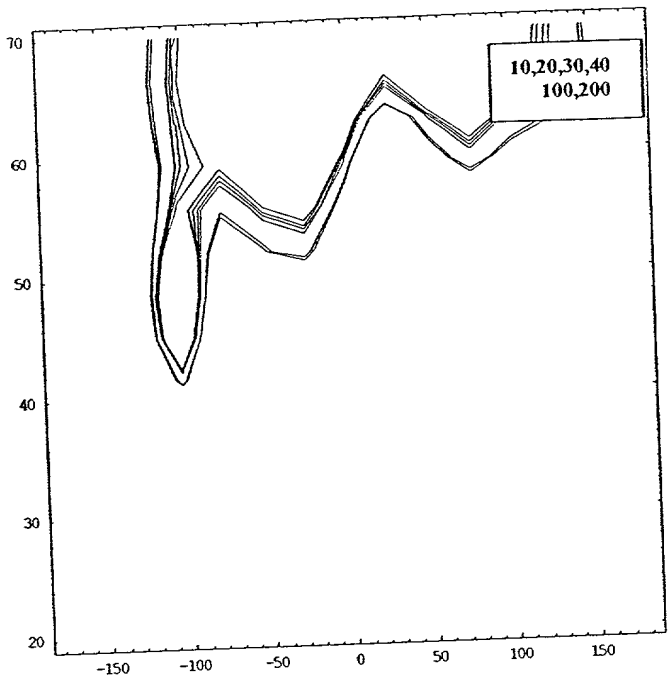
10,20,30,40
100,200
70
60
50
40
30
20
-150
-100
-50
0
50
100
150

Fig. 12

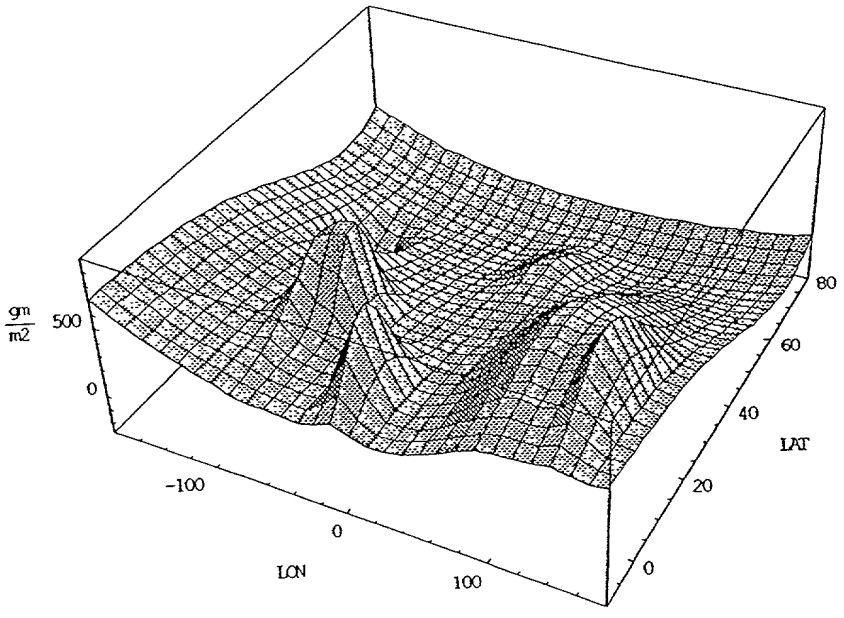
gm
m2
500
0
-100
0
100
LON
0
20
40
60
80
LAT

Fig. 13

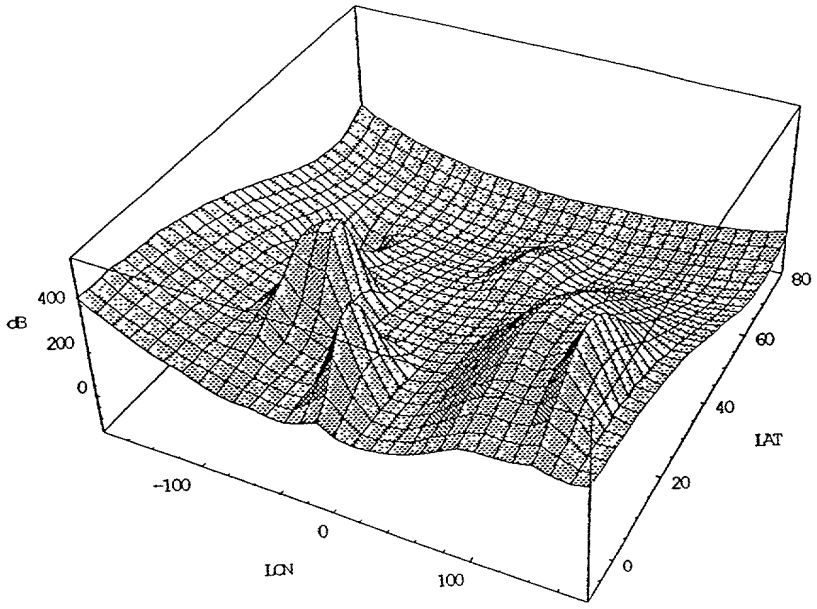
dB
400
200
0
-100
0
LON
100
0
20
40
60
80
LAT

Fig. 14

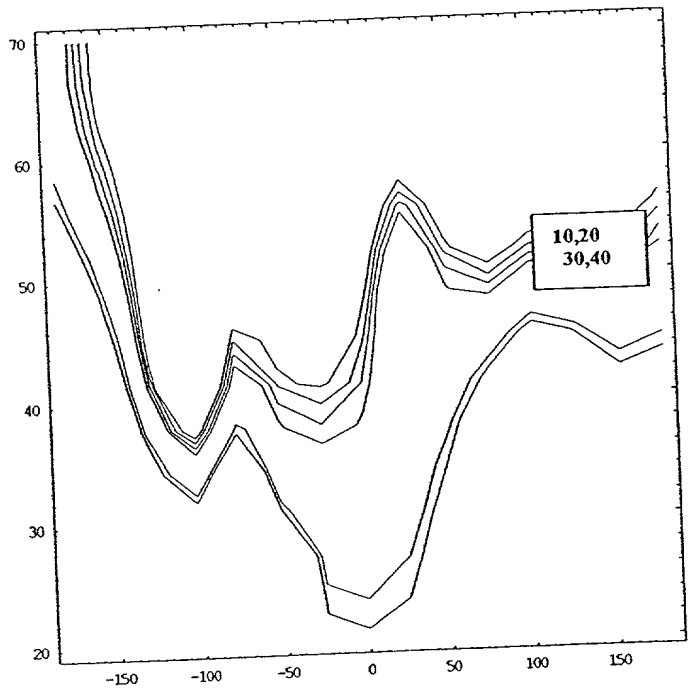
70
60
50
40
30
20
-150
-100
-50
0
50
100
150
10,20
30,40

Fig. 15

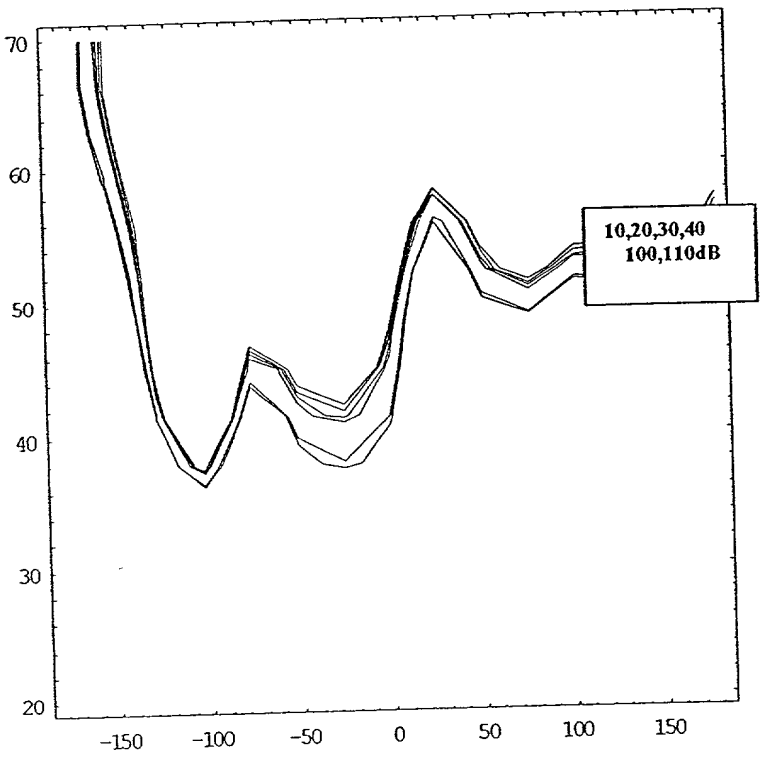

Fig. 16

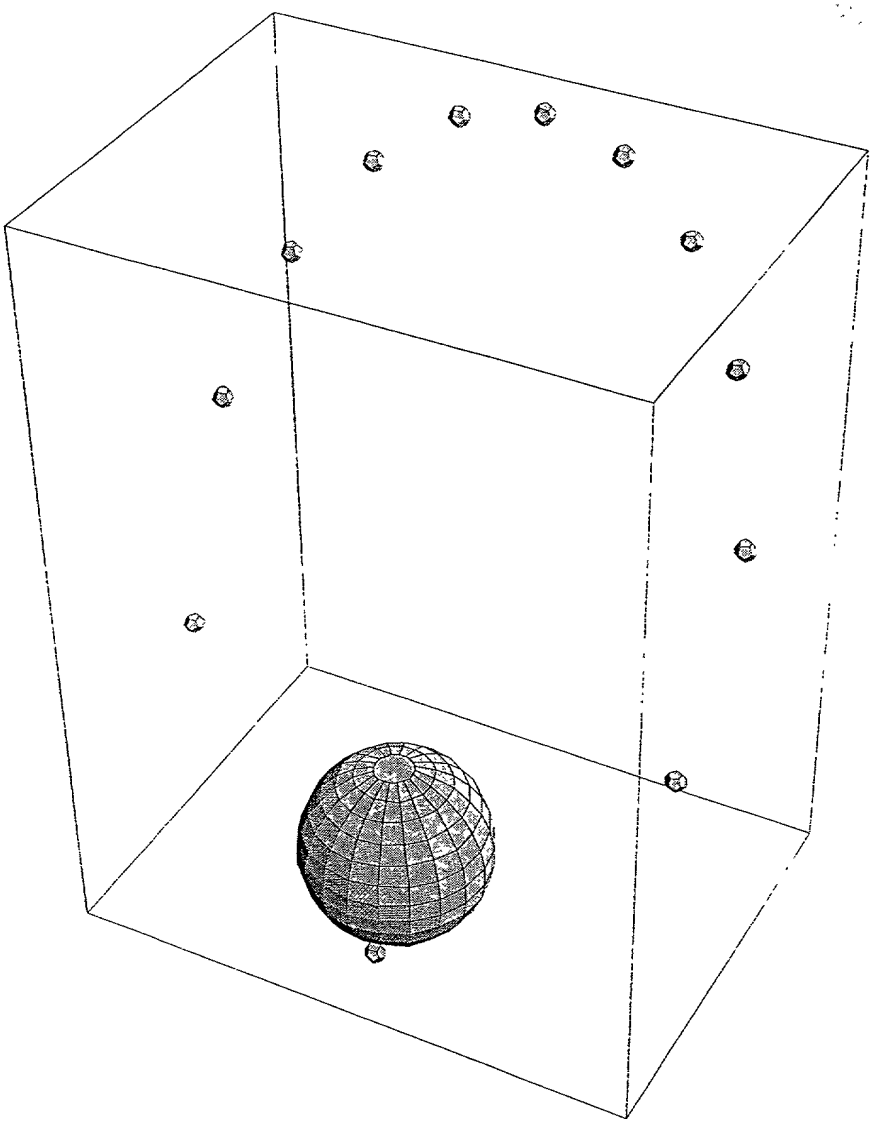

Fig. 17

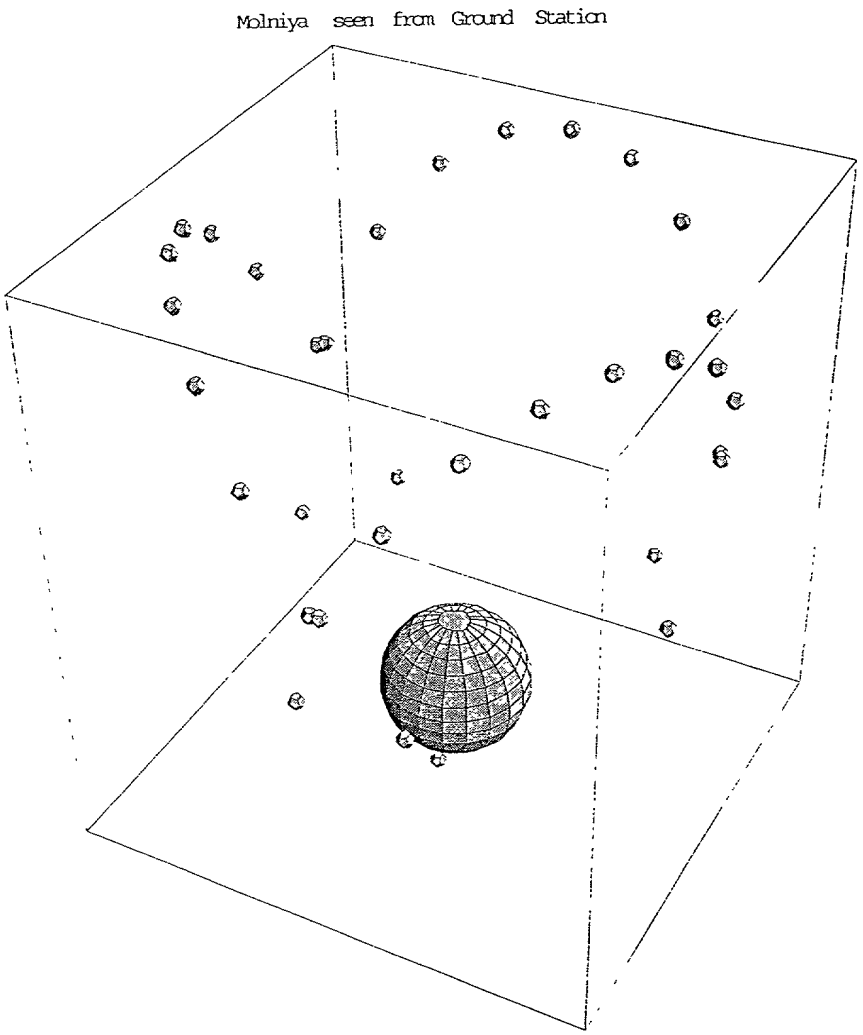

Fig. 18

MolniyaGEO pdf=

$$\frac{e^{-\frac{\left(5.22822\times10^{-6}\,LAT^4-0.000620006\,LAT^3+0.00512491\,LAT^2+0.165865\,LAT+x-47.0509\right)^2}{2\left(0.0000292838\,LAT^4-0.00526509\,LAT^3+0.270942\,LAT^2-0.776901\,LAT+181.722\,e^{-\frac{LAT^2}{900}}-160.041\right)^2}}}{\left(0.0000292838\,LAT^4-0.00526509\,LAT^3+0.270942\,LAT^2-0.776901\,LAT+181.722\,e^{-\frac{LAT^2}{900}}-160.041\right)\sqrt{2\pi}}$$

With x representing elevation angle in degrees.

Fig. 19

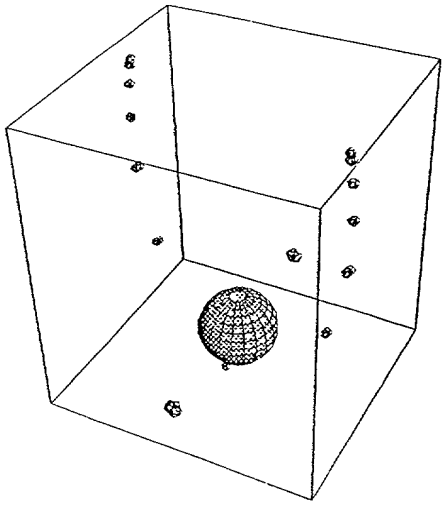

Fig. 20

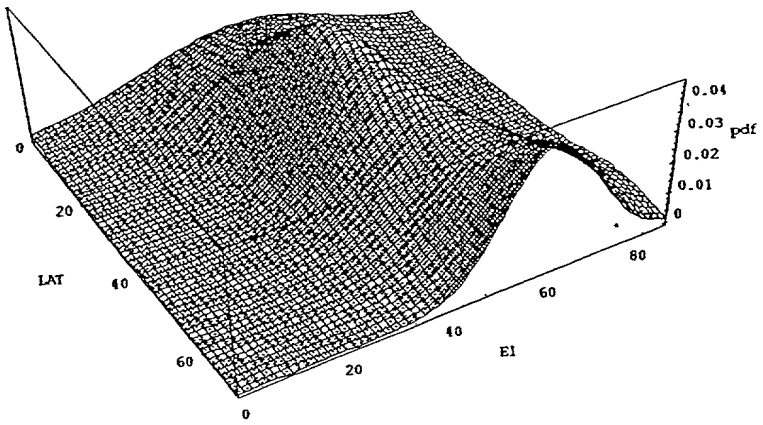

Fig. 21

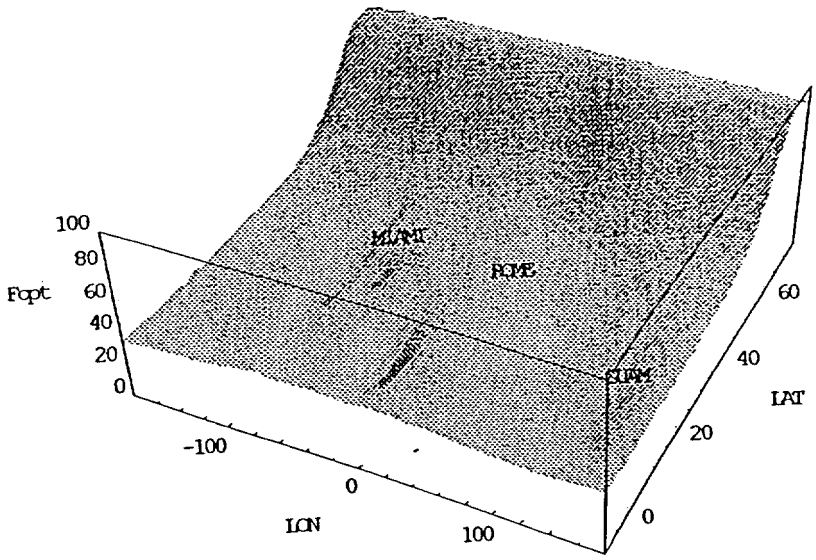

Fig. 22

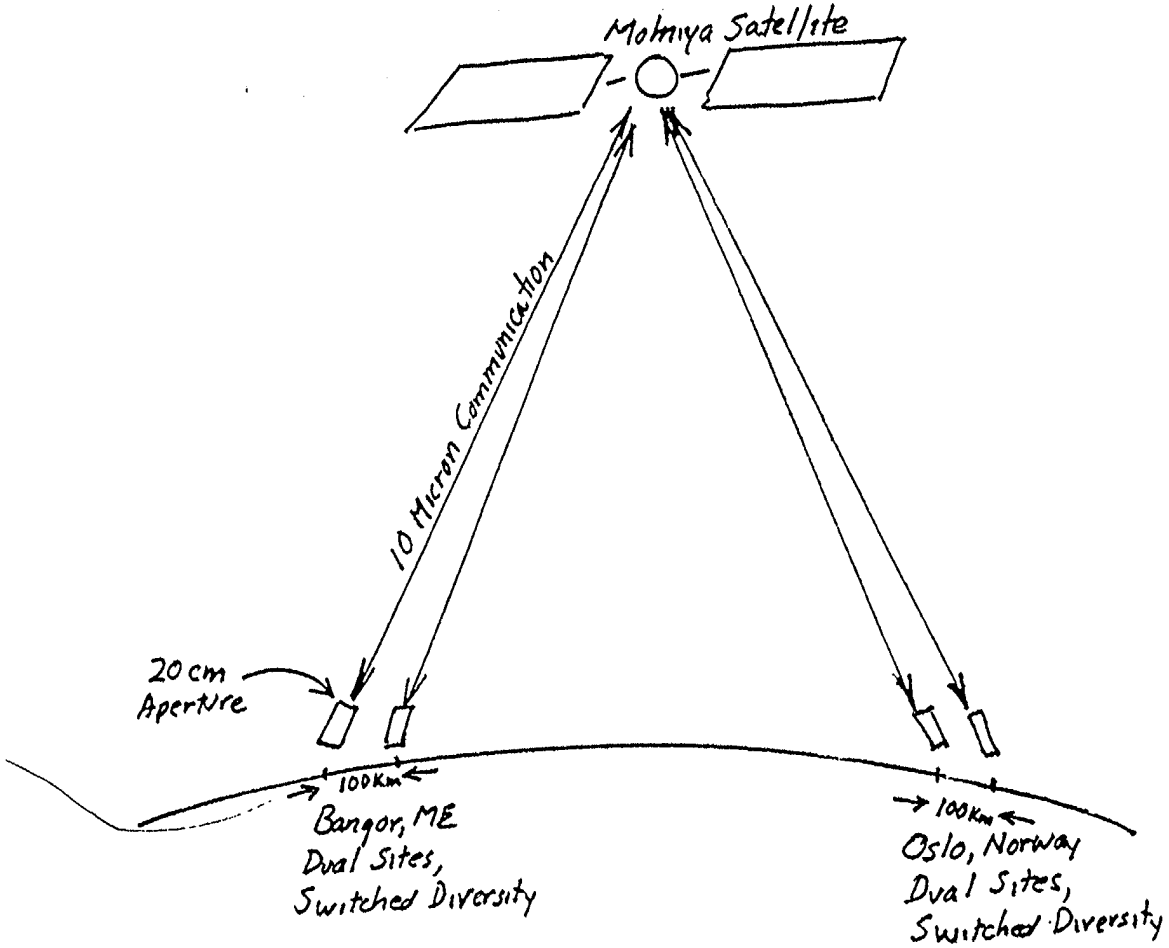
Molniya Satellite
10 Micron Communication
20 cm
Aperture
100Km
Bangor, ME
Dual Sites,
Switched Diversity
100Km
Oslo, Norway
Dual Sites,
Switched Diversity

Fig. 23

3832E0" 2S03S6S0

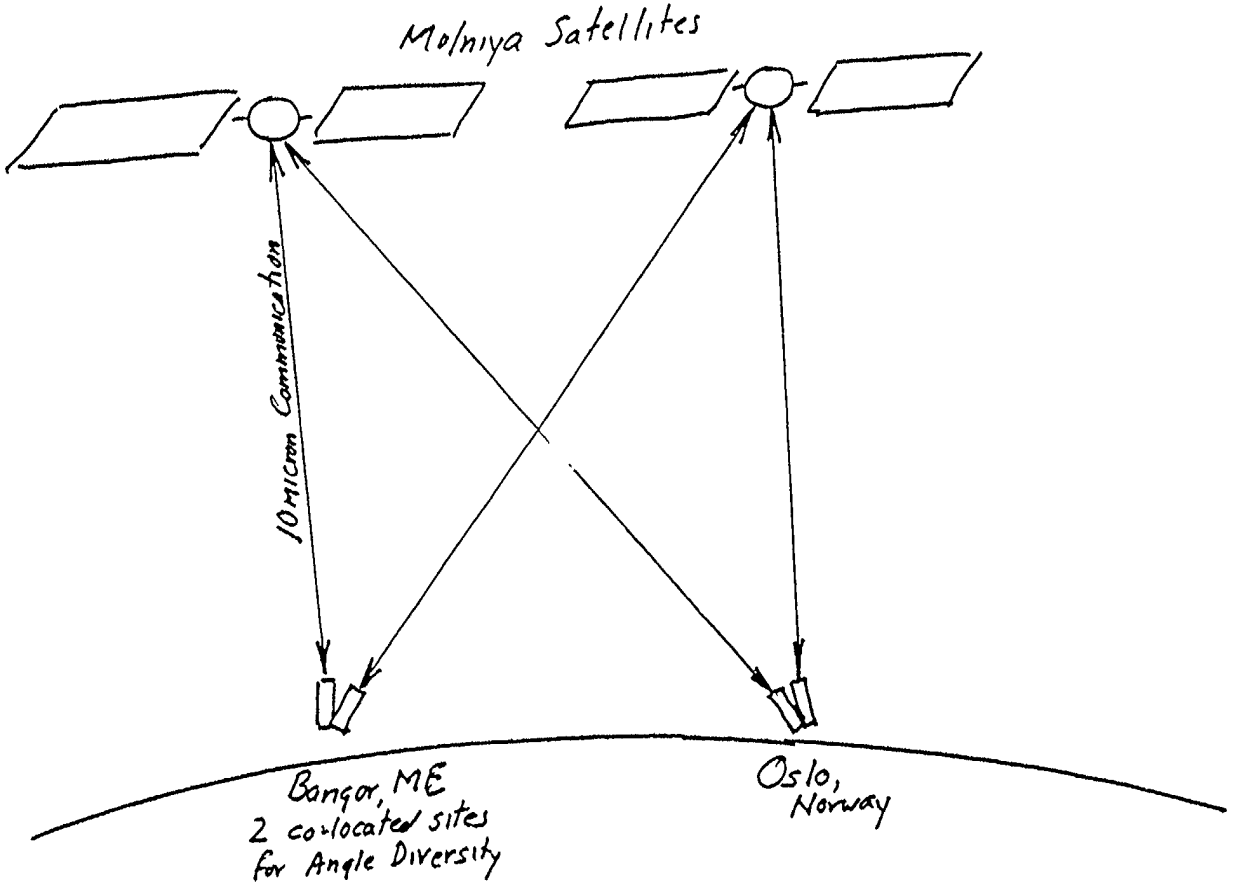

Fig. 24